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ENGINEERING DATA TRANSMITTAL 0052173

Page 1 of 2

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1	RPP-5417	N/A	0	Auto Tank Interpretive Report for Tank 241-AN-103	N/A	2	1	1
2	RPP-5418	N/A	0	Auto Tank Interpretive Report for Tank 241-AN-104	N/A	2	1	1
3	RPP-5419	N/A	0	Auto Tank Interpretive Report for Tank 241-AN-105	N/A	2	1	1
4	RPP-5420	N/A	0	Auto Tank Interpretive Report for Tank 241-AW-101	N/A	2	1	1

16. KEY

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5. Proj./Prog./Dept.Div.:	6. Cog. Eng.	1. EDT	Page 2 of 2
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15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
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5	RPP-5421	N/A	0	Auto Tank Interpretive Report for Tank 241-BY-105	N/A	2	1	1
6	RPP-5422	N/A	0	Auto Tank Interpretive Report for Tank 241-S-110	N/A	2	1	1
7	RPP-5423	N/A	0	Auto Tank Interpretive Report for Tank 241-S-111	N/A	2	1	1
8	RPP-5424	N/A	0	Auto Tank Interpretive Report for Tank 241-SX-102	N/A	2	1	1
9	RPP-5425	N/A	0	Auto Tank Interpretive Report for Tank 241-SX-105	N/A	2	1	1
10	RPP-5426	N/A	0	Auto Tank Interpretive Report for Tank 241-T-110	N/A	2	1	1
11	RPP-5427	N/A	0	Auto Tank Interpretive Report for Tank 241-U-107	N/A	2	1	1
12	RPP-5428	N/A	0	Auto Tank Interpretive Report for Tank 241-U-109	N/A	2	1	1
13	RPP-5429	N/A	0	Auto Tank Interpretive Report for Tank 241-U-112	N/A	2	1	1

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Auto Tank Interpretive Report for Tank 241-AN-103

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U.S. Department of Energy Contract DE-AC06-96RL13200

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This report prepared especially for Auto TIR on 11/09/99

Some of the reports herein may contain data that has not been reviewed or edited. The data will have been reviewed or edited as of the date that a Tank Interpretive Report (TIR) is prepared and approved. The TIR for this tank was approved on August 24, 1999.

Tank: 241-AN-103

Sampling Events:
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Reports:
Tank Interpretive Report

Constituent Groups:

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Data Dictionary to Reports in this Document

Report	Field	Description
Tank Interpretive Report		Interprets information about the tank answering a series of six questions covering areas such as information drivers, tank history, tank comparisons, disposal implications, data quality and quantity, and unique aspects of the tank.

Tank Interpretive Report For 241-AN-103

Tank Information Drivers

Question 1: What are the information drivers applicable to this tank? What type of information does each driver require from this tank? (Examples of drivers are Data Quality Objectives, Mid-Level Disposal Logic, RPP Operation and Utilization Plan, test plans and Letters of Instruction.) To what extent have the information and data required in the driving document been satisfied to date by the analytical and interpretive work done on this tank?

The information drivers for tank 241-AN-103 include the Flammable Gas Data Quality Objective (DQO), Tank Safety Screening DQO, Organic Solvent Safety Issue DQO, Low-Activity Waste (LAW) Feed DQO, Provide Samples to Contractor issue, Confirm Tank T is an Appropriate Feed Source for LAW Feed Batch X (Waste Feed Delivery) DQO, Regulatory Compliance Waste Disposal Integration Team (WIT) DQO, Air Emissions DQO, and Dangerous Waste DQO. As of the date this report was prepared, July 19, 1999, the sampling events associated with this tank did not address the issues of the Regulatory Compliance WIT DQO, the Air Emissions DQO, or the Dangerous Waste DQO. The remaining issues are discussed below.

Flammable Gas DQO: Does a possibility exist for releasing flammable gases into the headspace of the tank or releasing chemical or radioactive materials into the environment?

The requirements to support the flammable gas issue are documented in the *Data Quality Objective to Support Resolution of the Flammable Gas Safety Issue* (Bauer and Jackson 1998). The Flammable Gas DQO has been extended to apply to all tanks. Analyses and evaluations will change according to program needs until this issue is resolved. Final resolution of the flammable gas issue is expected to be completed by September 30, 2001 (Johnson 1997).

Retained gas samples (RGSs) from the 1996 tank 241-AN-103 core samples (core 166: segments 2, 5, and 14; core 167: segments 10, 13, and 16) were analyzed to address flammable gas issues. The results of RGS testing are reported in Shekarriz et al. (1997). The volumes of retained gas (at standard temperature and pressure and corrected for air entrainment) were 48 ± 3.0 m^3 in the crust, 8.8 ± 4.6 m^3 in the liquid, or convective layer, and 216 ± 22 m^3 in the solid, or nonconvective, layer. After correcting for air entrainment, the in-situ void fractions were 0.146 ± 0.015, 0.004 ± 0.001, and 0.077 ± 0.012 for the crust, convective, and nonconvective layers, respectively.

The retained gas was composed of three main constituents: nitrogen, hydrogen, and nitrous oxide. The concentrations of these constituents varied between waste layers. The remainder of the gas was composed of ammonia, methane, and other hydrocarbons. The lower-bound ammonia concentrations ranged from $1,260 \pm 350$ to $3,820 \pm 3,150$ μmoles per liter of waste. More than 99.9 percent of the ammonia is dissolved in the waste. The RGS analysis of ammonia is believed to underestimate the actual ammonia content in the tank by a factor of two to three (Shekarriz et al. 1997).

Since the release of Shekarriz et al. (1997), additional investigation of the tank 241-AN-103 retained gas has been performed. Meyer et al. (1997) evaluated the retained gas volume based on the RGS

samples and void fraction instrument measurements. Using these two inputs, mean void fractions of 0.15 ± 0.06, 0.004 ± 0.016, and 0.107 ± 0.011 were derived for the crust, convective, and nonconvective layers, respectively. These void fractions were used when calculating the retained gas volume for Best-Basis Inventory purposes. The retained gas volumes estimated in Meyer et al. (1997) were larger than those listed in Shekarriz et al. (1997). At standard temperature and pressure, Meyer et al. (1997) projected 56 ± 25 m^3 in the crust, 10 ± 36 m^3 in the convective layer, and 314 ± 31 m^3 in the nonconvective layer.

Tank 241-AN-103 is equipped with a standard hydrogen monitoring system (SHMS) for the collection of vapor-phase data that support resolution of flammable gas issues. The SHMS monitors hydrogen continuously and has been operating since September 1994. Through June 30, 1999, three hydrogen gas release events (GREs) have been documented for tank 241-AN-103 based upon SHMS data. These GREs occurred in August 1995, April 1998, and February 1999. The maximum concentration of hydrogen released was 3,000 ppm on August 22, 1995. This is well below the action level of 6,250 ppm of hydrogen (Jones 1999). The releases in 1995 and 1998 are documented in the report *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks* (McCain and Bauer 1998). The 1999 GRE is currently documented in the SHMS Monitoring Monthly Report for February 1999 (McCain 1999) and will be included in the 1999 revision of McCain and Bauer (1998).

Safety Screening DQO: Does the waste pose or contribute to any recognized potential safety problems?

The data needed to screen the waste in tank 241-AN-103 for potential safety problems are documented in *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). These potential safety problems are exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste.

The threshold limit for energetics is 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry (DSC) indicated that no exothermic reactions (on a dry weight basis) exceeded the threshold limit. The maximum dry-weight DSC value measured was 268 J/g (from the drainable liquid of segment 2 of core 167). The DSC analysis on the solids of segment 2 of core 167 were rerun because of a large difference in the initial wet-weight results (primary: 97.6 J/g; duplicate: 358 J/g). The rerun provided results of 93.1 and 51.1 J/g wet-weight, which is equivalent to 153 and 83.7 J/g on a dry-weight basis. All upper limits to a one-sided 95 percent confidence interval on the mean DSC results were below the 480 J/g notification limit except for core 167, segment 7, drainable liquid, which had a dry-weight upper limit of 629 J/g. The upper limit was high because of the difference in the DSC data found for the two samples (primary: 0 J/g, duplicate 172.0 J/g). In addition, the weight percent water for this sample was 48.4. These results suggest that energetics are not a concern for this tank.

Vapor phase measurements, taken in the tank headspace prior to the push core samples in September 1996, indicated that no flammable gas was detected (0 percent of the lower flammability limit [LFL]) (see *"IH Sniff Data"* Standard Report). Other headspace measurements also made in 1996 gave results of 0 percent of the LFL. The peak hydrogen concentration during the three recorded GREs was 3,000 ppm (McCain and Bauer 1998), which is less than the 6,250-ppm limt (25 percent of the LFL).

The threshold limit for criticality is 1 g/L of plutonium. Assuming that all alpha activity is from ^{239}Pu, and using the maximum segment sample density of 1.93 g/mL, 1 g/L of ^{239}Pu is equivalent to 32 μCi/g of alpha activity for the crust and salt slurry and 61.5 μCi/mL of alpha activity for the supernatant. Concentrations in all samples were well below this limit, with the largest detected values in the solids and supernatant being 0.0429 μCi/g and 0.18 μCi/mL, respectively. Additionally, as required by the DQO, the upper limits to a one-sided 95 percent confidence interval on each sample mean were calculated. All upper limits were well below the criticality decision limits, with the maximum value being 0.534 μCi/mL. Therefore, criticality is not a concern for this tank.

Organic Solvent Safety Issue DQO: Does an organic solvent pool exist that may cause a fire or ignition of organic solvents in entrained waste solids?

The data required to support the organic solvent screening issue are documented in the *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue* (Meacham et al. 1997). The DQO requires tank headspace samples be analyzed for total nonmethane organic compounds. The purpose of this assessment is to ensure that an organic solvent pool fire or ignition of organic solvent cannot occur.

No vapor samples have been taken from tank 241-AN-103 to estimate the organic pool size. However, the organic program has determined that even if an organic solvent pool does exist, the consequence of a fire or ignition of organic solvents is below risk evaluation guidelines for all tanks (Brown et al. 1998). The organic solvent issue is expected to be closed for all tanks in 1999.

LAW Feed DQO: Do the samples taken from tank 241-AN-103 and the subsequent laboratory analyses meet the needs of the privatization LAW Feed DQO?

Tank 241-AN-103 was sampled and analyzed in support of privatization based on the requirements documented in the *Low-Activity Waste (LAW) Feed Data Quality Objectives* (Wiemers and Miller 1997). The purpose of the LAW Feed DQO (Wiemers and Miller 1997) was to address technical issues pertinent to pretreatment, immobilization, and balance-of-plant for LAW processing. Waste was to be characterized to determine whether it fell within the defined process design envelope. Data collected in support of this DQO were to be used primarily for planning activities of the privatization contractors as specified in the privatization request for proposals.

Tank 241-AN-103 was push-mode core sampled in September 1996. In 1998, archived material from the 1996 core samples was subsampled and analyzed in accordance with the *Request to Perform Additional Analysis for Tank 241-AN-103 for Privatization Project* (Wilkins 1998). Three solid subsamples were prepared from the 1996 core 166 solid composite, and three liquid subsamples were prepared from a composite (formed in 1998) of the 1996 core 166 segments 3, 4, 6, 7, 8, 9, 10, 11, and 12.

The 222-S Laboratory performed the analysis according to the requirements of the LAW Feed DQO (Wiemers and Miller 1997). The results from these analyses are reported in Esch (1998). Kinzer (1999) directed that the following statistical calculations be performed on this data:

- the mean concentration ($\hat{\mu}$) of the composite subsample results,
- the standard deviation of the mean $SD(\hat{\mu}) = S/\sqrt{n}$, and
- the relative standard deviation (RSD) associated with the mean ($RSD(\hat{\mu}) = (SD(\hat{\mu})/\hat{\mu}) \times 100$). Both $SD(\hat{\mu})$ and $RSD(\hat{\mu}) = (SD(\hat{\mu})/\hat{\mu}) \times 100$ represent the random variability associated with the analytical measurements.

The mean, the SD of the mean, and the RSD on the mean are reported in Table 1-1. Table 1-2 provides a comparison of the ratio of each analyte to sodium with the Envelope A contract limits. The Envelope A contract limits are reported as a ratio of moles of analyte to moles of sodium. The LAW Feed DQO (Wiemers and Miller 1997) establishes a sensitivity boundary around the envelope limits of $\pm$ 30%. For tank 241-AN-103, all constituents analyzed met the Envelope A contract limits for LAW. As seen in Table 1-2, only two analytes (chloride: 75.90% and hydroxide: 75.80%) fell within the sensitivity boundary.

The current data needed to support privatization waste processing and disposal are documented in the *Low-Activity Waste and High-Level Waste Feed Processing Data Quality Objectives* (Patello et al. 1999). This revised DQO imposes additional sampling, compositing, and analytical requirements that address the Privatization contract's allowance for entrained solids to be processed as LAW, high-level waste (HLW), or returned to tank farms. Additionally, the DQO accommodates the LAW and HLW treatment scenario, allowing for liquids separated from HLW feed to be treated as LAW feed. Further sampling and analysis of tank 241-AN-103 may be required to meet these revised DQO requirements.

Table 1-1. Variance Components For Tank 241-AN-103 Supernatant Composite Means.[1]

Constituent	Analysis Method Group	Units	Mean	SD (mean)	%RSD (mean)
Aluminum	ICP	µg/mL	31,800	229	0.721
Barium	ICP	µg/mL	<30.1	n/a	n/a
Cadmium	ICP	µg/mL	5.09	0.140	2.75
Calcium	ICP	µg/mL	<60.1	n/a	n/a
Chloride	IC	µg/mL	11,000	201	1.83
Chromium	ICP	µg/mL	592	3.03	0.512
Fluoride	IC	µg/mL	660	38.1	5.77
Hydroxide	OH	µg/mL	99,700	2,500	2.50
Iron	ICP	µg/mL	<30.1	n/a	n/a
Lanthanum	ICP	µg/mL	<30.1	n/a	n/a
Lead	ICP	µg/mL	143	3.00	2.10
Mercury	ICP	µg/mL	<0.0500	n/a	n/a
Nickel	ICP	µg/mL	<12.0	n/a	n/a
Nitrate	IC	µg/mL	1.23E+05	551	0.447
Nitrite	IC	µg/mL	1.32E+05	1,330	1.01
Phosphate	IC	µg/mL	<903	n/a	n/a
Potassium	ICP	µg/mL	17,300	180	1.05
Sodium	ICP	µg/mL	2.54E+05	2,780	1.10

Table 1-1. Variance Components For Tank 241-AN-103 Supernatant Composite Means.[1]

Constituent	Analysis Method Group	Units	Mean	SD (mean)	%RSD (mean)
Sulfate	IC	μg/mL	<1,000	n/a	n/a
Total inorganic carbon	TIC/TOC	μg/mL	1,160[2]	5.00	0.433
Total organic carbon	TIC/TOC	μg/mL	3,050[2]	25.0	0.821
U_{TOTAL}	ICP/MS	μg/mL	<5.41[3]	n/a	n/a
TRU[4]	Alpha Rad	μCi/mL	<0.00653[2]	n/a	n/a
^{137}Cs	GEA	μCi/mL	802	9.94	1.24
$^{89/90}Sr$	Sr-89/90	μCi/mL	0.0208[2]	0.00	0.00
^{99}Tc	Technetium	μCi/mL	0.159[5]	0.00242	6.87

Notes:

IC = ion chromatography
TIC = total inorganic carbon
TOC = total organic carbon
GEA = gamma energy analysis
n/a = not applicable

[1]Means derived from 1998 composite results unless noted otherwise.
[2]Mean derived from 1996 composite results.
[3]Derived by summing results for the individual uranium isotopes as measured by inductively coupled plasma/mass spectroscopy (ICP/MS). Included is atomic mass unit (AMU)-238 data, which is assumed to be U-238. Approximately 55 percent of this total is from a detected result (AMU-238); the remainder is a sum of detection limits.
[4]Transuranic (TRU) activity is represented by the total alpha activity.
[5]Based on the 1998 composite AMU-99 data because the 1996 liquid scintillation data is considered suspect.

Table 1-2. Comparison of Tank 241-AN-103 Supernatant Results to Envelope A Contract Limits.[1]

Analyte	Average (μg/mL)	Average (M)	Ratio (Avg/Na)	Envelope Limit (moles analyte/moles Na)	Found Analyte/Env. Spec. [(Avg/Na)/Env. Spec.]
			A	B	A/B
Al	3.18E+04	1.18E+00	1.07E-01	1.9E-01	56.14%
Ba	3.01E+01[2]	2.19E-04	1.98E-05	1.0E-04	19.84%
Ca	6.01E+01[2]	1.50E-03	1.36E-04	4.0E-02	0.34%
Cd	5.09E+00	4.53E-05	4.10E-06	4.0E-03	0.10%
Cl	1.10E+04	3.10E-01	2.81E-02	3.7E-02	75.90%
Cr	5.92E+02	1.14E-02	1.03E-03	6.9E-03	14.93%
F	6.60E+02	3.47E-02	3.14E-03	9.1E-02	3.46%
Fe	3.01E+01[2]	5.39E-04	4.88E-05	1.0E-02	0.49%

Table 1-2. Comparison of Tank 241-AN-103 Supernatant Results to Envelope A Contract Limits.[1]

Analyte	Average (µg/mL)	Average (M)	Ratio (Avg/Na)	Envelope Limit (moles analyte/moles Na)	Found Analyte/Env. Spec. [(Avg/Na)/Env. Spec.]
			A	B	A/B
Hg	5.00E-02[2]	2.49E-07	2.26E-08	1.4E-05	0.16%
K	1.73E+04	4.42E-01	4.00E-02	1.8E-01	22.25%
La	3.01E+01[2]	2.17E-04	1.96E-05	8.3E-05	23.63%
Na	2.54E+05	1.10E+01	1	1	100.00%
Ni	1.20E+01[2]	2.04E-04	1.85E-05	3.0E-03	0.62%
NO_2	1.32E+05	2.87E+00	2.60E-01	3.8E-01	68.34%
NO_3	1.23E+05	1.98E+00	1.80E-01	8.0E-01	22.44%
OH	9.97E+04	5.86E+00	5.31E-01	7.0E-01	75.80%
Pb	1.43E+02	6.90E-04	6.25E-05	6.8E-04	9.19%
PO_4	9.03E+02[2]	9.51E-03	8.61E-04	3.8E-02	2.26%
SO_4	1.00E+03[2]	1.04E-02	9.42E-04	9.7E-03	9.71%
TIC (P)	1.16E+03	9.66E-02	8.74E-03	3.0E-01	2.91%
TOC (P)	3.05E+03	2.54E-01	2.30E-02	6.0E-02	38.31%
U ICP/MS	5.41E+00[2]	2.27E-05	2.06E-06	1.2E-03	0.17%
Analyte	**µCi/mL**	**Bq/L**	**Ratio (Avg/Na)**	**(Bq analyte/moles Na)**	**Found Analyte/Env. Spec. [(Avg/Na)/Env. Spec.]**
TRU	6.53E-03[2]	2.42E+05	2.19E+04	4.8E+05	4.56%
^{137}Cs	8.02E+02	2.97E+10	2.69E+09	4.3E+09	62.46%
^{90}Sr	2.08E-02	7.70E+05	6.97E+04	4.4E+07	0.16%
^{99}Tc	1.68E-04	6.22E+03	5.63E+02	7.1E+06	0.01%

Notes:

[1]Mean concentrations were reported previously. See Table 1-1 for additional notes.

[2]Mean concentration is a non-detected value.

Provide Samples to Contractor issue: Have the required samples been provided to the Privatization Contractor?

The Waste Disposal Division and WIT identified the need for tank waste samples to be provided to the Privatization Contractor for process validation work prior to the commencement of hot operations. Tank 241-AN-103 was core sampled in September 1996. Following the analyses, the remaining sample material was archived as directed by the sampling and analysis plan (Kruger 1996). In September 1998, 1.5 liters of archived material were shipped to the Privatization Contractor, thus satisfying the requirements of BNFL (1998).

Waste Feed Delivery DQO: Does the waste feed meet specifications as a feed source for tank waste privatization?

The current data required to support waste feed delivery for Phase I LAW are documented in *Data Quality Objectives for TWRS Privatization Phase I: Confirm Tank T is an Appropriate Feed Source for Low-Activity Waste Feed Batch X* (Nguyen 1999). Archived material from the 1996 tank 241-AN-103 core sampling event will be used to study the dilution of this waste since retrieval of the tank waste will require dilution to dissolve solids. The solids solubility screening tests are scheduled to be performed in 2000.

Heat Load Estimate:

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. The heat load estimate based on the process history was 6,690 W (22,800 Btu/hr) (Agnew et al. 1997a). The Kummerer (1995) heat load estimate derived from radionuclide concentrations was 13,200 W (45,000 Btu/hr). The heat load estimated from the Best-Basis Inventory is 10,700 W (36,500 Btu/hr), as shown in Table 1-3. All of these estimates are below the 20,500 W (70,000 Btu/hr) operating specification limit for the AN Tank Farm (Fowler 1999).

Table 1-3. Heat Load Estimate Based on the Best-Basis Inventory.

Radionuclide	Waste Inventory[1] (Ci)	Specific Activity (W/Ci)	Heat Load (W)
^{90}Sr	8,800	0.00670	59.0
^{137}Cs	2.24E+06	0.00472	10,600
Total			10,700

Note:
[1]See *"Best-Basis Inventory Estimate (Radioactive Components)"* Standard Report.

Tank History

Question 2: What is known about the history of this tank as it relates to waste behavior?

The 241-AN Tank Farm was constructed from 1980 to 1981 in the 200 East Area. The tank farm contains seven double-shell tanks, each with a capacity of 4,390 kL (1,160 kgal) and a diameter of 22.9 m (75.0 ft). These tanks were designed to hold boiling waste with a maximum design temperature of 177 °C (350 °F) (Brevick et al. 1997). Tank 241-AN-103 was constructed with a primary carbon steel liner, a secondary carbon steel liner, and a reinforced concrete shell. Twenty-two risers provide access to the interior of the primary tank. Additional tank descriptive material is contained in the following Standard Reports: *"Tank Plan View"*; *"Tank Profile View"*; and *"Riser Configuration Table"*.

Water was initially added to tank 241-AN-103 in the second quarter of 1982 in order to test the tank's integrity. The first waste transfers occurred in the fourth quarter of 1982, with the receipt of dilute non-complexed waste from tank 241-SY-102 (Agnew et al. 1997b). By the end of January 1983, the tank was nearly empty, having transferred most of its waste to tank 241-AW-102. Beginning in the third quarter of 1983 and continuing through the third quarter of 1984, tank 241-AN-103 received salt well liquor from salt well pumping of a variety of single-shell tanks. Also during this time the tank received dilute, non-complexed waste from the 300 and 400 areas and from B Plant cesium processing, and waste from tank 241-AN-104. A transfer of waste from tank 241-AN-103 to tank 241-AN-101 is recorded in the fourth quarter of 1984. Between the first quarter of 1984 and the first quarter of 1986, tank 241-AN-103 participated in several evaporator campaigns, exchanging waste with tank 241-AW-102. With the conclusion of the evaporator campaign in the first quarter of 1986, transfers of waste to tank 241-AN-103 ceased. Small amounts of water have been added to the tank over the years. Minor fluctuations in the surface level have been observed as a result of slurry growth caused by the gas generation in the waste. Occasional lancing of the crust has been performed to release the retained gas (Agnew et al. 1997b).

Tank 241-AN-103 presently contains an estimated 3,618 kL (956 kgal) of double-shell slurry waste (Hanlon 1999) made up of three layers: a floating crust, a convective (supernatant) layer, and a non-convective (salt slurry) layer. The estimated volumes for these layers are 150 kL (40 kgal) for the crust, 1,881 kL (497 kgal) for the supernatant, and 1,386 kL (366 kgal) for the salt slurry (see Table 7-1 of this Tank Interpretive Report). A total of 201 kL (53 kgal) of retained gas is estimated in the tank waste. Tank 241-AN-103 is listed as sound and is actively ventilated. The tank is on the Flammable Gas Watch List (Public Law 101-510).

Tank Comparisons

Question 3: What other tanks have similar waste types and waste behaviors, and how does knowledge of the similar tanks contribute to the understanding of this tank?

Tank 241-AN-103 is a flammable gas-containing tank that has experienced GREs. Other double-shell tanks on the flammable gas watch list include tanks 241-SY-101, 241-SY-103, 241-AW-101, 241-AN-104, and 241-AN-105. Similar to tank 241-AN-103, these tanks also have a history of gas releases. Of the six double-shell flammable gas watch list tanks, tank 241-AN-103 has had the fewest number of GREs, with only three recorded since the SHMS was installed in September 1994 (McCain and Bauer 1998; McCain 1999). Meyer et al. (1997) compared the visual appearance of extruded segments for each of these six tanks and related this information to GREs and gas retention. The extrusions generally showed that the tanks with the larger, more frequent GREs have wetter, less firm waste. Those storing the most gas have generally dryer, stiffer waste with more bubbles visible in the cores. Consistent with these observations, tank 241-AN-103 had some of the stiffest waste observed and, according to the Meyer et al. (1997) calculations, contained the largest volume of retained gas among the six double-shell flammable gas watch list tanks.

According to Hanlon (1999), tank 241-AN-103 contains double-shell slurry (DSS). Double-shell slurry is waste that has been concentrated past the sodium aluminate saturation boundary. No comparisons with other DSS tanks are possible, however, because tank 241-AN-103 is the only tank on the Hanford Site that contains exclusively DSS.

Agnew et al. (1997a) indicates that the waste in tank 241-AN-103 is primarily Supernatant Mixing Model type A2 (SMMA2) waste. Tanks 241-AN-102, 241-AN-104, 241-AN-105, and 241-AN-107 also contain SMMA2 waste and contribute to an understanding of the waste in tank 241-AN-103. Of these tanks, the supernatant and solids volumes in tanks 241-AN-104 and 241-AN-105 most closely resemble the volume distribution in tank 241-AN-103.

Agnew et al. (1997a) predicts that the bottom 8 kL (2 kgal) of waste in tank 241-AN-103 is B Plant low-level (BL) waste. This volume of waste converts to a waste layer of less than one inch. Because the BL waste comprises such a small portion of the bottom segment, results from this segment are more representative of SMMA2 waste rather than BL waste. The best information to represent BL waste is from grab samples of the upper sludge taken from tank 241-C-106 in 1996 before the recent sluicing.

Disposal Implications

Question 4: Given what is known about the waste properties and waste behaviors in this tank, what are the implications of the waste properties and behaviors to the waste retrieval/processing methodologies and equipment selection?

Given what is known about the waste types and behaviors in tank 241-AN-103, there are several items that should be considered with regard to waste retrieval. Tank 241-AN-103 is on the Watch List for the flammable gas issue, is thermally hot, and contains a significant crust layer at the waste surface, all of which may affect retrieval of the waste.

A major concern for this tank is the retained gas in the crust, supernatant, and salt slurry layers. Because of the stiff, relatively dry nature of the salt slurry and the thick crust layer, most of the gas generated is retained in the waste. The RGS data and measurements using a void fraction instrument and ball rheometer indicate that the waste in tank 241-AN-103 retains the most gas of any of the six double-shell flammable gas watch list tanks (Meyer et al. 1997). This assertion is supported by the SHMS data, as only 3 GREs have been recorded in the past five years and the baseline concentration of hydrogen in the headspace is nearly zero volume percent (McCain and Bauer 1998). Bubbles were observed in all of the extruded 1996 solid segments. The concern for retrieval is that waste disturbance and transfer could release the retained gas and generate flammable gas concentrations in the tank headspace greater than the lower flammability limit. Consequently, flammable gas issues should be carefully considered before waste retrieval methods are implemented.

Also of concern from an industrial health perspective are the toxic gases retained in the waste. Ammonia, nitrous oxide, and methane were all measured in the RGS segments. Issues regarding worker safety should be further evaluated before disturbing the waste.

Another possible problem that may be encountered during waste retrieval and transfer is the precipitation of solids from the supernatant layer. At the time of the core sampling (September 1996), temperatures in the supernatant layer ranged between 43.3 and 46.1 °C (110 and 115 °F). Upon extrusion of the core samples, all of the supernatant segments contained solids as a result of precipitation caused by cooling. Recent temperatures have averaged slightly lower than those recorded in 1996 (see Standard Report "*Tank Temperature Profile*"). However, methods for preventing the plugging of transfer lines should be investigated before any waste transfers are made.

Finally, tank 241-AN-103 contains a significant crust layer. Based on the extrusion results, the Best-Basis Inventory estimated the thickness at 43 cm (17 in.) (see Question 7 for more information); other estimates have ranged as high as 92 cm (36 in.) (Meyer et al. 1997). The layer was sampled using push-mode, indicating that it does not appear to be extremely hard.

A dissolution study was performed in 1987 using waste from the lower eight segments of a 1986 core from tank 241-AN-103. The study tested the effects of time, dilution ratio (water:waste), and agitation on the rate of dissolution. The test was run at 10 °C (50 °F), and it was found that most of the solids readily dissolved at that temperature. Agitation had a large effect on the rate of dissolution. For example, 50 percent of the solids were found to have dissolved after ten minutes of agitation, while the nonagitated sample took 140 hours to reach 50 percent dissolution. Complete dissolution of the solids was not achieved in either the agitated or nonagitated samples. Approximately 10 percent of the solids did not dissolve in the agitated sample after performing the test for 20 hours. Nearly 30 percent of the solids remained in the 1:1 diluted (water:waste) nonagitated sample after standing for nine days. Further information is provided in Prignano (1988).

Scientists Assessment of Data Quality and Quantity

Question 5: Given the current state of understanding of the waste in this tank on the one hand and the information drivers on the other; should additional tank data be sought via sampling/analysis from a strictly technical point-of-view? Can the waste behavior in this tank be adequately understood by other means (eg. archive samples, tank grouping studies, modeling) without additional sampling and analysis? If so, what characteristics of the tank waste lend themselves to a non-sample alternative? Is the quality of the data from this tank adequate from a field sampling and analytical laboratory point-of-view? Are there any clarifications or explanations needed for the data tables and figures?

Sampling and Analysis

The following DQOs and waste issues have been addressed for this tank and accepted by the Project Hanford Management Contract River Protection Project (RPP): Flammable Gas, Safety Screening, and Organic Solvent. No additional sampling or analyses are necessary to satisfy current safety issue requirements for this tank. Further action may be identified to address the Waste Feed Delivery DQO, LAW Feed DQO, Regulatory Compliance WIT DQO, Air Emissions DQO, and Dangerous Waste DQO.

The Waste Feed Delivery DQO requires a dilution study on the tank 241-AN-103 solids for retrieval purposes. This study is scheduled to occur in fiscal year 2000.

More sampling and analysis may be necessary to meet the additional requirements of the recently issued *Low-Activity Waste and High-Level Waste Feed Processing Data Quality Objectives* (Patello et al. 1999). Given the schedule for Phase I retrieval, this additional analytical/physical information has a high priority.

Finally, to date, no sampling has been performed to address the issues of the Regulatory Compliance WIT DQO, Air Emissions DQO, or Dangerous Waste DQO. These activities will be scheduled as needed to meet the Retrieval Program requirements.

Data Quality

The data collected in the core sampling event were collected and analyzed with approved and recognized sampling and laboratory procedures and in accordance with Kruger (1996) and Wilkins (1998). The laboratory procedures for the core sample analysis can be found in the Standard Report *"Analytical Methods and Procedures."* Quality Control (QC) parameters assessed in conjunction with tank 241-AN-103 samples included standard recoveries, spike recoveries, duplicate analyses, and blanks. Appropriate QC footnotes were applied to data outside QC parameter limits. Analytical results and data quality are discussed in Steen (1997) and Esch (1998).

High relative percent differences (RPDs) were observed for many analytes. In most cases, the high RPDs were attributed to sample heterogeneity and no reruns were performed. One DSC analysis on a solids segment was redone because of substantial differences between the primary and duplicate results. The rerun results were more consistent, although the RPD still exceeded the QC limit. Selected thermogravimetric analysis (TGA) samples were reanalyzed due to high RPDs. The RPDs obtained during the reanalysis were below QC parameters. For tritium, the high RPD for the 1996 liquid core composite was attributed to a small amount of ^{137}Cs contamination present on the duplicate aliquot mount. Steen (1997) states that this contamination is unavoidable in samples containing high levels of ^{137}Cs. The sample was analyzed three times due to the ^{137}Cs contamination.

Several analytes had spike recoveries outside the requested limits. For aluminum, potassium, sodium, nitrate, and nitrite, the poor spike recoveries were attributed to the high concentration of these analytes in the samples with respect to the amount of spike standard added. Therefore, the matrix spike recovery results for these analytes should not be used as a means to determine the accuracy of the results. Post digestion spikes were run for aluminum, potassium, and sodium, and acceptable results were obtained. In addition, serial dilutions were performed on the aluminum, potassium, and sodium samples that had matrix spike recovery problems. The results for all serial dilutions, except for one on a potassium sample, indicate that the accuracy of the analyses was acceptable. Other IC analytes and uranium had poor spike recoveries because of matrix interferences.

Low levels of beta activity were noted in some of the 1996 core composite preparation blanks. However, the levels of contamination are inconsequential when compared to the result of the sample and do not impact sample data quality (Steen 1997). A similar situation was observed for aluminum, silicon, and ^{79}Se in the 1998 drainable liquid composite.

The vast majority of QC results were within the boundaries specified in the sampling and analysis plans. Small discrepancies noted in the analytical reports and footnoted in the *"Analytical Results"* Standard Report should not impact the data validity or use.

Hydrostatic head fluid (HHF) was used during the 1996 core sampling event. Based on the lithium and bromide results and associated weight percent water corrections, less than 10 percent contamination was observed for all segments.

Segments 2, 5, and 14 from core 166 and segments 10, 13, and 16 from core 167 were sampled using the retained gas sampler. These samples were only used for flammable gas assessments. The RGS results are reported in Shekarriz et al. (1997). Segment 18 of core 167 was intended to be an RGS sample. However, the valve did not close on the sampler, so no material was retrieved.

Clarification and Explanation of Data Tables and Figures

"Description of Tank" Standard Report: The waste phase volumes in this Standard Report differ from those reported in Hanlon (1999) because the retained gas volumes have been subtracted out of the totals. For additional discussion, refer to Question 7, "Best-Basis Inventory Derivation."

"Core Profile" Standard Report: As shown in this Standard Report, solids were recovered in the supernatant segments. However, it should not be construed that this is the actual configuration in the tank. Because of temperature differences between the tank and the laboratory hotcell, it is likely that the observed solids in these segments precipitated after removal from the tank.

"Tank Subsampling Scheme and Sample Description" and *"Analytical Results"* Standard Reports: The *"Tank Subsampling Scheme and Sample Description"* Standard Report shows that 250 mL of liquid were recovered for segment 4 of core 167. Analytical data for this material is not included in the *"Analytical Results"* Standard Report, however, because the sample was dropped in the lab before analysis and could not be recovered.

"Analytical Results" and *"Means and Confidence Intervals"* Standard Reports: As seen in the *"Analytical Results"* Standard Report, some of the samples were prepared for analysis by ICP using a potassium hydroxide fusion in a nickel crucible. This preparation method contaminates the nickel and potassium results. Consequently, means for these analytes from the fusion preparation were not included in the *"Means and Confidence Intervals"* Standard Report.

Unique Aspects of the Tank

Question 6: What are unique chemical, physical, historical, operational or other characteristics of this tank or its contents?

A unique characteristic of tank 241-AN-103 is its waste type based on evaporator operations. Tank 241-AN-103 is the only tank on the Hanford Site that contains exclusively double-shell slurry (Hanlon 1999). The waste in this tank was concentrated past the sodium aluminate saturation boundary in the evaporator. For other double-shell tanks that received evaporator waste, concentration was stopped before reaching the sodium aluminate saturation boundary.

Some unique characteristics were noted in the 1996 data package (Steen 1997) and the RGS data report (Shekarriz et al. 1997). Thermograms from the DSC analysis for several samples showed small sharp peaks near 200 °C (392 °F), which indicated a decomposition of a pure compound. While x-raying the RGS samples during the 1996 core sampling, technicians observed large gas pockets in the waste. These gas pockets account for a large portion of the measured void fraction (Shekarriz et al. 1997).

Best-Basis Inventory Derivation

Question 7: What is the source data used to derive this tank's Best-Basis inventories by mass (kg) and activity (Ci) for the standard list of 25 chemicals and 46 radionuclides?

The Best-Basis Inventory program is chartered to develop and maintain Best-Basis Inventories of 25 chemical and 46 radionuclide components in the 177 Hanford Site underground storage tanks. These Best-Basis Inventories now serve as waste composition data for the RPP process flowsheet modeling work, safety analyses, risk assessments, and waste retrieval, treatment, and disposal system design.

Development and maintenance of the Best-Basis Inventory is an on-going effort. Since new sample data was recently made available for double-shell tank 241-AN-103, a re-evaluation of the Best-Basis Inventories was performed and is documented in the following text. The following information was used in this evaluation:

- Statistical means from the 1996 analyses of the tank 241-AN-103 1996 core samples (cores 166 and 167) (see *"Means and Confidence Intervals"* Standard Report).
- Statistical means from archived 1996 core material analyzed in 1998 (see *"Means and Confidence Intervals"* Standard Report)
- The Hanford Defined Waste (HDW) model document (Agnew et al. 1997a) which provides tank content estimates in terms of component concentrations and inventories.

The following tables represent how the available data is used to derive Best-Basis Inventories for tank 241-AN-103. Analyses were performed on the individual segments from the 1996 core sampling, allowing separation of the data by waste phase. As can be seen in Table 7-1, three waste phases were present in the tank: crust, supernatant, and salt slurry. Inventories were computed separately for each waste phase and then summed to obtain an overall tank inventory. The volumes reported in Table 7-1 will be reflected in a future update to the Waste Tank Summary Report (Hanlon 1999).

Liquid and solid composites were formed from core 166 and analyzed both in 1996 and 1998. However, the compositing method rendered the composite samples representative of the overall tank liquid and solid fractions instead of specific waste layers. For the solids composite, an equal amount of solids were taken from all segments that had solids, including the supernatant segments whose solids formed as a result of cooling and were not representative of the salt slurry or crust. The liquid composite did not contain any of the supernatant solids, and was therefore not representative of the supernatant as it exists in the tank. For these reasons, the composite data were not used to represent specific waste layers. Instead, the composite data were used to derive inventories for the tank solid and liquid fractions as shown in Table 7-2. These inventories were then summed to obtain an overall tank inventory.

Table 7-1. Tank 241-AN-103 Best-Basis Inventory Source Data by Waste Phase.

Waste Phase	Waste Type	Applicable Concentration Data	Associated Density	Associated Volume
Crust	SMMA2 (DSS)	1996 segment data	1.66	150 kL (40 kgal)
Supernatant	SMMA2 (DSS)	1996 segment data	1.49[1]	1,881 kL (497 kgal)
Salt slurry	SMMA2 (DSS)	1996 segment data	1.73	1,386 kL (366 kgal)
Retained gas	n/a	n/a	n/a	201 kL (53 kgal)
Total tank[2]	Overall tank volume			3,618 kL (956 kgal)

Notes:

[1]Calculated density value

[2]The HDW model volume was 3,607 kL (953 kgal) with a density of 1.60 g/mL. The difference in volume is attributed to slurry growth from the retained gas.

Table 7-2. Tank 241-AN-103 Best-Basis Inventory Source Data by Waste Fraction.

Waste Fraction	Waste Type	Applicable Concentration Data	Associated Density	Associated Volume
Liquids	SMMA2 (DSS)	1998 composite of liquids from core 166[1]	1.49[2]	1,605 kL (424 kgal)
		1996 composite of liquids from core 166[1]	1.49	
Solids	SMMA2 (DSS)	1998 composite of solids from core 166[3]	1.69[2]	1,813 kL (479 kgal)
		1996 composite of solids from core 166[3]	1.69	
Retained gas	n/a	n/a	n/a	201 kL (53 kgal)
Total tank[4]	Overall tank volume			3,618 kL (956 kgal)

Notes:

[1]Composite was formed from the liquids of core 166 only. None of the solids that precipitated from the liquid were included in the analysis.

[2]Density not analyzed; 1996 density is assumed.

[3]Composite was formed using solids from all segments that had them. Consequently, included in the analysis were crust solids, supernatant solids, and salt slurry solids.

[4]The HDW model volume was 3,607 kL (953 kgal) with a density of 1.60 g/mL. The difference in volume is attributed to slurry growth from the retained gas.

Best-Basis Inventory Derivation by Waste Phase. The waste phases in Table 7-1 (salt slurry, supernatant, and crust) were based on the core sampling extrusion results and the analytical results (see *"Means and Confidence Intervals"* Standard Report). The following discussion describes the

derivation of volumes and densities for these waste phases. Throughout this discussion, note that segments 2, 5, and 14 of core 166 and segments 10, 13, 16, and 18 of core 167 were taken using the retained gas sampler.

The salt slurry volume is based on a 1997 assessment that evaluated ball rheometer measurements, temperature readings, and the core sampling data (Stauffer 1997). For core 166, segments 13 through 19 were considered salt slurry, while segments 12 through 18 and the solids from segment 11 were designated salt slurry for core 167. (Note that because of an uneven waste surface, there is an offset of one segment between the cores, i.e., segment 19 of core 166 is at the same depth as segment 18 of core 167 [see "*Core Profiles*" Standard Report]). The split between the salt slurry solids and the supernatant solids was based on the analytical results and the extrusion data. Substantial differences in concentration were observed between the salt slurry and supernatant solids for certain chemicals. Possibly the best indicator of solids type was aluminum. Aluminum concentrations in the salt slurry solids generally ranged between 50,000 and 105,000 μg/g, while the concentration in the supernatant solids varied from 6,000 μg/g to just over 15,000 μg/g. The density reported in Table 7-1 for the salt slurry phase is a mean of the analytical results from bulk density measurements.

The crust volume was based on the core 167 extrusion results and the analytical data. Fourteen inches of solids, and no drainable liquid, were obtained in the first segment of core 167. The second segment consisted of six inches of solids and 190 mL of liquid (see "*Tank Subsampling Scheme and Sample Description*" Standard Report). However, all six inches of solids from this segment are not likely crust. Nearly all of the supernatant segments unexpectedly had solids when extruded at the 222-S laboratory. Because temperatures in the tank range up to 40.6 °C (105 °F) (see "*Tank Temperature Profile*" Standard Report), it is believed that the solids in the supernatant segments actually precipitated when the segments cooled to ambient temperatures after removal from the tank. The six inches of solids from segment 2 of core 167 is likely a combination of these precipitated solids and crust solids. Therefore, it was assumed that half of the solids, or 7.6 cm (3 in.), was crust while the other half was supernatant solids. The total crust depth is then 43 cm (17 in.). The core 166 extrusion results were not used in deriving a crust volume because the second segment was taken using the retained gas sampler. The Table 7-1 density for the crust is the mean from bulk density measurements on the crust material.

The supernatant volume was derived by subtracting the salt slurry and crust volumes from the overall waste volume. As just described, most of the supernatant segments contained solids upon extrusion at the laboratory due to precipitation from cooling. The solids and liquids were analyzed separately. To derive a true supernatant mean, the solid and liquid data were combined based on weight percent weighting factors. The combination was done on a segment basis. The supernatant density value reported in Table 7-1 is a calculated mean derived according to the combination method.

The current overall tank volume, 3,618 kL (956 kgal), is in agreement with surveillance information (see "*Tank Surface Level*" Standard Report). The HDW model total tank volume, 3,607 kL (953 kgal), differs from the current tank volume because of slurry growth from the retained gas; no actual waste transfers have occurred between 1994 and July 1999. The retained gas volume was derived using the waste phase mean void percentages reported in Meyer et al. (1997). These mean void percentages are the average gas volume fractions computed from retained gas samples and void fraction instrument readings. Note that the retained gas volume reported in Table 7-1 differs slightly

from that reported in Meyer et al. (1997) because of differences in waste phase volumes. The Table 7-1 retained gas volume also differs from that derived solely from the retained gas samples as reported in Shekarriz et al. (1997) and Question 1 of this Tank Interpretive Report. The volumes used to compute the Best-Basis Inventory do not include the retained gas volumes. Note that because the *"Description of Tank"* Standard Report does not contain an entry for retained gas volume, the reported phase volumes will not add up to the total volume.

The waste type designations were based on tank process history (Agnew et al. 1997a). For Best-Basis purposes, all of the waste has been attributed to SMMA2. Agnew et al. (1997a) predicts that an 8 kL (2 kgal) layer of BL waste exists on the bottom. Because the layer is so small (less than one inch), it is difficult to tell if it was sampled or even exists. A very small amount of BL waste was received during the process history, and the waste was received during periods in which the tank already contained a significant amount of waste. Even if the layer does exist and was sampled, it would not be apparent from the analytical data because any concentration differences between the BL and SMMA2 waste types would be lost due to the fact that the BL waste makes up such a small amount of the last segment. The DSS term is used by Hanlon (1999) to represent waste that has been concentrated past the sodium aluminate saturation boundary during processing through an evaporator.

Only one sample-based concentration vector was available for each of the waste phases (crust, supernatant, and salt slurry). These vectors were based on the 1996 segment analyses. As described previously, the supernatant concentration means were calculated by combining solid and liquid data for each segment. Analysis of the metals in all three waste phases was performed after both fusion and acid digestions. In most cases, the higher of the results from the two digestion methods was used for the Best-Basis Inventory. If one of the values was below detection limits and the other detected, then the detected result was used. Where both values were below detection limits, the lowest of the nondetected values was used. For the salt slurry sodium mean, the acid digestion result was used instead of the fusion value, although it was lower. This was done because mass and charge balances revealed that the acid digestion mean was more reasonable.

Where possible, the inventories based on waste phases were used over the inventories based on waste fractions. If both inventories were based on nondetected results, the lower of the two was used.

Best-Basis Inventory Derivation by Waste Fraction. As described previously, the composites analyzed in 1996 and 1998 were actually representative of the overall tank solids and liquids instead of specific waste phases. Therefore, separate concentration vectors were available for the tank fractions as shown in Table 7-2. The following discussion describes the derivation of volumes and densities for these waste fractions.

The volumes of the liquid and solids waste fractions listed in Table 7-2 were calculated as a percentage of the total waste volume (less the retained gas). To derive the volume percentage of each waste fraction, individual segment volume percentages were determined and then averaged. These individual segment percentages were determined across cores (i.e., at each sampling depth). When determining the average, the first segment of core 166 was not weighted the same as the other segment depths because only 6.4 cm (2.5 in.) of waste were obtained, and there was no segment taken at the same depth in core 167 (see "*Core Profiles*" Standard Report). Because 6.4 cm (2.5 in.) is only 13 percent of the volume of a full segment, segment 1 of core 166 was only weighted 13 percent of the rest of the segment depths.

Densities and specific gravities for the solid and liquid waste fractions were determined on the 1996 composites. Since no such measurements were made on the 1998 composites, the 1996 mean values are assumed.

For the waste fraction vectors, the 1998 composite data were used when available. The 1996 composite data were used to supplement the 1998 data.

The ^{99}Tc Best-Basis Inventory was based on the solid and liquid waste fractions. As a result of concerns regarding the radiochemical results from the 1996 liquid analysis, the ^{99}Tc concentration for the liquid fraction was based on the AMU-99 data from the 1998 inductively coupled plasma/mass spectrometry (ICP/MS) analysis. There appears to be a three order of magnitude discrepancy between these two sets of results. The ICP/MS results match what is expected based on results from tanks containing similar waste types, and they are in more reasonable agreement with the ^{99}Tc concentrations in the solids fraction.

Total Tank Best-Basis Inventory Derivation. For analytes without data from either of the sample-based methods, the HDW model values were used to derive inventories. Model values were also used for analytes in some cases where the value was lower than a nondetected sample-based result.

All inventory calculations were performed using the Best-Basis Inventory Maintenance Tool. The updated Best-Basis Inventory values for tank 241-AN-103 can be found in the "*Best-Basis Inventory (Non-Radionuclides)*" and "*Best Basis Inventory (Radionuclides)*" Standard Reports. Once the Best-Basis Inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997a).

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